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(amended) Claims

1. A battery pack charge/discharge control apparatus for controlling charge/discharge of a battery pack (12) that is formed by combining a plurality of unit batteries (10) of a secondary battery type, comprising:

charge/discharge restriction means (200) for restricting the charge/discharge based on at least one of a capacity upper limit value and a capacity lower limit value of the unit batteries (10) constituting the battery pack (12);

remaining capacity detection means (14, 200) for detecting remaining capacities of unit batteries (10) constituting the battery pack (12);

control value computation means (200) for computing a control state-of-charge value based on at least one of a minimum value (Qmin) and a maximum value (Qmax) of the detected remaining capacities;

capacity difference computation means (200) for computing, as a capacity difference (Qd), a remaining capacity difference between the remaining capacity of a first unit battery and the remaining capacity of a second unit battery among the unit batteries (10) whose remaining capacities have been detected, the remaining capacity of the second unit battery being less than the remaining capacity of the first unit battery;

storage means (200) for storing a correlation between the capacity difference (Qd) and an apparent state-of-charge value (apparent SOC) that is different from the control state-of-charge value (representative SOC);

apparent state-of-charge value computation means (200) for computing an apparent state-of-charge value (apparent SOC) with reference to the correlation based on the capacity difference (Qd); characterized by further comprising:

apparent state-of-charge value adoption means for adopting the apparent state-of-charge value (apparent SOC) if the capacity difference (Qd) is at least a predetermined capacity difference (Q2) that is stored beforehand.

2. The battery pack charge/discharge control apparatus according to claim 1, characterized in that the capacity difference computation means (200) includes maximum remaining capacity detection means for detecting a unit battery (10) having a maximum remaining capacity (Qmax) in the battery pack (12), and minimum remaining capacity detection means for detecting a unit battery (10) having a minimum remaining capacity (Qmin) in the battery pack (12), and computes a remaining capacity difference between the maximum remaining capacity (Qmax) and the minimum remaining capacity (Qmin) as a capacity difference (Qd).

3. The battery pack charge/discharge control apparatus according to any one of claims 1 or 2, characterized by further comprising control state-of-charge value adoption means for adopting the minimum remaining capacity (Qmin) of the unit batteries (10) constituting the battery pack (12) or a percentage of the minimum remaining capacity (Qmin) to a fully charged capacity value (Qfull), as a control state-of-charge value (representative SOC) for controlling the battery pack (12), if the capacity difference (Qd) is less than a pre-stored predetermined capacity difference (Q2).

4. The battery pack charge/discharge control apparatus according to any one of claims 1 through 3, characterized in that if the capacity difference (Qd) is at least a pre-stored predetermined capacity difference maximum value, the predetermined capacity difference maximum value is adopted instead of the capacity difference (Qd).

5. The battery pack charge/discharge control apparatus according to any one of claims 1 through 4, characterized in that the correlation is expressed by Mathematical Expression (1):

$$SOC = \frac{SOCmid - SOClow}{Qhigh - Qlow - Qd} \times (Q\min - Qlow) + SOClow \quad (1)$$

where SOC is the apparent state-of-charge value, and SOCmid is a control center value of the state-of-charge value, and SOClow is a lower limit set value of the state-of-charge value, and SOChigh is an upper limit set value of the state-of-charge value, and Qlow is a capacity value converted from SOClow, and Qhigh is a capacity value converted from SOChigh, and Qd is the capacity difference, and Qmin is the minimum remaining capacity, and Qmax is the maximum remaining capacity.

6. The battery pack charge/discharge control apparatus according to claim 5, characterized in that if in Mathematical Expression (1), the denominator on the right-hand side which is presented as Mathematical Expression (2) is at most a predetermined zero-cross reduction preventative value (Q3), the zero-cross reduction preventative value (Q3) is adopted in place of the denominator expressed by Mathematical Expression (2):

$$Qhigh - Qlow - Qd \quad (2)$$

7. The battery pack charge/discharge control apparatus according to claim 5 or 6, characterized in that if in Mathematical Expression (1), SOC becomes greater than a maximum guard value, the maximum guard value is adopted in place of the term on the left-hand side in Mathematical Expression (1).

8. The battery pack charge/discharge control apparatus according to any one of claims 5 through 7, characterized in that if in Mathematical Expression (1), SOC becomes less than a minimum guard value (MIN guard value), the minimum guard value (MIN guard value) is adopted in place of the term on the left-hand side in Mathematical Expression (1).

9. A battery pack charge/discharge control apparatus for controlling charge/discharge of a battery pack (12) that is formed by combining a plurality of unit batteries (10) of a secondary battery type, comprising:

remaining capacity detector (14, 200) that detects remaining capacities of unit batteries (10) constituting the battery pack (12); and

controller (200) that restricts the charge/discharge based on at least one of a capacity upper limit value and a capacity lower limit value of the unit batteries (10) constituting the battery pack (12),

computes a control state-of-charge value based on at least one of a minimum value (Qmin) and a maximum value (Qmax) of the detected remaining capacities,

computes as a capacity difference (Qd), a remaining capacity difference between the remaining capacity of a first unit battery and the remaining capacity of a second unit battery among the unit batteries (10) whose remaining capacities have been detected, the remaining capacity of the second unit battery being less than the remaining capacity of the first unit battery,

stores a correlation between the capacity difference (Qd) and an apparent state-of-charge value (apparent SOC) that is different from the control state-of-charge value (representative SOC),

computes an apparent state-of-charge value (apparent SOC) with reference to the correlation based on the capacity difference (Qd), characterized in that the controller (200)

adopts the apparent state-of-charge value (apparent SOC) if the capacity difference (Qd) is at least a predetermined capacity difference (Q2) that is stored beforehand.

10. The battery pack charge/discharge control apparatus according to claim 9, characterized in that the controller (200) detects a unit battery (10) having a maximum remaining capacity (Qmax) in the battery pack (12) and a unit

battery (10) having a minimum remaining capacity (Qmin) in the battery pack (12), and computes a remaining capacity difference between the maximum remaining capacity (Qmax) and the minimum remaining capacity (Qmin) as a capacity difference (Qd).

11. The battery pack charge/discharge control apparatus according to any one of claims 9 or 10, characterized in that the controller (200) adopts the minimum remaining capacity (Qmin) of the unit batteries (10) constituting the battery pack (12) or a percentage of the minimum remaining capacity (Qmin) to a fully charged capacity value (Qfull), as a control state-of-charge value (representative SOC) for controlling the battery pack (12), if the capacity difference (Qd) is less than a pre-stored predetermined capacity difference (Q2).

12. The battery pack charge/discharge control apparatus according to any one of claims 9 through 11, characterized in that if the capacity difference (Qd) is at least a pre-stored predetermined capacity difference maximum value, the predetermined capacity difference maximum value is adopted instead of the capacity difference (Qd).

13. The battery pack charge/discharge control apparatus according to any one of claims 9 through 12, characterized in that the correlation is expressed by Mathematical Expression (1):

$$SOC = \frac{SOCmid - SOClow}{Qhigh - Qlow - Qd} \times (Q\min - Qlow) + SOClow \quad (1)$$

where SOC is the apparent state-of-charge value, and SOCmid is a control center value of the state-of-charge value, and SOClow is a lower limit set value of the state-of-charge value, and SOChigh is an upper limit set value of the state-of-charge value, and Qlow is a capacity value converted from SOClow, and Qhigh is a capacity value converted from SOChigh, and Qd is

the capacity difference, and Qmin is the minimum remaining capacity, and Qmax is the maximum remaining capacity.

14. The battery pack charge/discharge control apparatus according to claim 13, characterized in that if in Mathematical Expression (1), the denominator on the right-hand side which is presented as Mathematical Expression (2) is at most a predetermined zero-cross reduction preventative value (Q3), the zero-cross reduction preventative value (Q3) is adopted in place of the denominator expressed by Mathematical Expression (2):
Qhigh – Qlow – Qd (2)

15. The battery pack charge/discharge control apparatus according to claim 13 or 14, characterized in that if in Mathematical Expression (1), SOC becomes greater than a maximum guard value, the maximum guard value is adopted in place of the term on the left-hand side in Mathematical Expression (1).

16. The battery pack charge/discharge control apparatus according to any one of claims 13 through 15, characterized in that if in Mathematical Expression (1), SOC becomes less than a minimum guard value (MIN guard value), the minimum guard value (MIN guard value) is adopted in place of the term on the left-hand side in Mathematical Expression (1).

17. A battery pack charge/discharge control method for controlling charge/discharge of a battery pack that is formed by combining a plurality of unit batteries of a secondary battery type, comprising the following steps of:
restricting the charge/discharge based on at least one of a capacity upper limit value and a capacity lower limit value of the unit batteries (10) constituting the battery pack (12);
detecting remaining capacities of unit batteries (10) constituting the battery pack (12);

computing a control state-of-charge value based on at least one of a minimum value (Qmin) and a maximum value (Qmax) of the detected remaining capacities;

computing, as a capacity difference (Qd), a remaining capacity difference between the remaining capacity of a first unit battery and the remaining capacity of a second unit battery among the unit batteries (10) whose remaining capacities have been detected, the remaining capacity of the second unit battery being less than the remaining capacity of the first unit battery;

storing a correlation between the capacity difference (Qd) and an apparent state-of-charge value (apparent SOC) that is a state-of-charge value different from the control state-of-charge value (representative SOC);

computing an apparent state-of-charge value (apparent SOC) with reference to the correlation based on the capacity difference (Qd); characterized by comprising the further step:

adopting an apparent state-of-charge value (apparent SOC) if the capacity difference (Qd) is at least a predetermined capacity difference (Q2) that is stored beforehand.

18. A battery pack charge/discharge control program that is read into a computer so as to control charge/discharge of a battery pack that is formed by combining a plurality of unit batteries of a secondary battery type, characterized by comprising:

restricting the charge/discharge based on at least one of a capacity upper limit value and a capacity lower limit value of the unit batteries (10) constituting the battery pack (12);

detecting remaining capacities of unit batteries (10) constituting the battery pack (12);

computing a control state-of-charge value (representative SOC) based on at least one of a minimum value (Qmin) and a maximum value (Qmax) of the detected remaining capacities;

computing, as a capacity difference (Qd), a remaining capacity difference between the remaining capacity of a first unit battery and the remaining capacity of a second unit battery among the unit batteries (10) whose remaining capacities have been detected, the remaining capacity of the second unit battery being less than the remaining capacity of the first unit battery; and

computing an apparent state-of-charge value (apparent SOC) that is different from the control state-of-charge value (representative SOC), with reference to a correlation between the capacity difference (Qd) and the apparent state-of-charge value (apparent SOC).